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# Social-ecological dynamics of the small scale fisheries in Sundarban Mangrove Forest, Bangladesh

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## ABSTRACT

The Sundarban Mangrove Forest (SMF) is an intricate ecosystem containing the most varied and profuse natural resources of Bangladesh. This study presents empirical research, based on primary and secondary data, regarding the social-ecological system (SES), social-ecological dynamics, different stakeholders and relevant management policies of small-scale or artisanal fisheries such as the SMF; showing how, despite extensive diversification, the livelihood activities of the artisanal fishers in the SMF all depend on the forest itself. Regardless of this critical importance of mangroves, however, deforestation continues due to immature death of mangroves, illegal logging, increased salinity, natural disasters and significant household consumption of mangrove wood by local people. As the mangroves are destroyed fish stocks, and other fishery resources are reduced, leading to moves of desperation among those whose livelihood has traditionally been fishing. The present study also considers several risks and shock factors in the fishers' livelihood: attacks by wild animals (especially tigers) and local bandits, illness, natural disasters, river bank erosion, and the cost of paying off corrupt officials. The artisanal fishers of the SMF have adopted different strategies for coping with these problems: developing partnerships, violating the fisheries management laws and regulations, migrating, placing greater responsibility on women, and bartering fishing knowledge and information. This study shows how the social component (human), the ecological component (mangrove resources) and the interphase aspects (local ecological knowledge, stakeholder's interest, and money lenders or middle man roles) of the SMF as an SES are linked in mutual interaction. It furthermore considers how the social-ecological dynamics of the SMF have negative impacts on artisanal fishermen's livelihoods. Hence there is an urgency to update existing policies and management issues for the sustainable utilization of the SMF resources, eventually contributing to the improvement of the artisanal fishers' livelihoods.

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## 1. Introduction

### 1.1. Artisanal fisheries and the Sundarban Mangrove Forest (SMF)

Artisanal or small-scale fisheries involves a consistent fleet, made up of small vessels with low tonnage. Unlike the large-scale fishing industry, the artisanal segment relies on small capital investments and is characterized using rather diversified fishing gear

(Farrugio, Oliver, & Biagi, 1993). Artisanal fishing activities vary significantly from one to another, depending not only on biological and environmental conditions but also on the social, economic and historical contexts in which fishers live (Battaglia, Romeo, Consoli, Scotti, & Andaloro, 2010). Small-scale fisheries are critically important as sources of nutrition, income, and well-being for hundreds of millions of people around the world. They are a vitally important interface between people and marine or aquatic resources, depending heavily on the health and resilience of these marine and aquatic ecosystems (Allison et al., 2009). Despite their importance, however, studies regarding the artisanal fishery sector — characteristics of their fleets and fishing gear, seasonality,

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catches, yields, revenues, and costs — have been somewhat limited. This is particularly important in that understanding and reducing the impacts of artisanal fisheries on marine ecosystems is a rapidly emerging priority for marine conservation. In the context of ecosystems being degraded, ever-growing human populations and increasing efforts required in artisanal fishing, there is urgent need to develop sustainable management strategies for artisanal fisheries (Johnson et al., 2013).

Mangrove forest is one of the primary features of coastlines throughout the tropics and subtropics globally (Alongi, 2002). As the source of a variety of renewable resources, mangroves play a significant role in the local economy and livelihood of the people who live among them, in the national economic development of tropical coastal nations, and in the regional environmental balance (Islam & Wahab, 2005). Mangroves have direct, tangible value as a source of timber, fuelwood, and fruit; and indirect value through their functions as a coastal shelter belt, tourist attractions, feeding and breeding ground for fish and wildlife, and as a source of floral biodiversity unto themselves. These values result from intrinsic characteristics of the mangrove ecosystem and its continuous interaction with other ecosystems (Iftekhar & Islam, 2004). Furthermore, mangroves are characterized by higher biodiversity in their fisheries as well as higher standing stock (Chong, Sasekumar, Leh, & D'Cruz, 1990).

The Sundarbans is a unique mangrove ecosystem of considerable ecological and economic value, a world heritage site and the most significant mangrove forests in the world, shared between Bangladesh (62%) and India (Iftekhar & Islam, 2004). The total land area is 4143 km<sup>2</sup>, surrounded by a water area of 1874 km<sup>2</sup> composed of rivers, small streams, and canals. The Sundarbans form an ideal mangrove ecosystem, supporting vast stocks of fish, shrimp and edible crab which supply a staple food and income for the coastal communities (Hoq, 2003). With over 3.5 million people in the surrounding areas depending directly or indirectly on the Sundarbans for their livelihood, the forest has been shrinking alarmingly day by day (Shah, Huq, & Rahman, 2010). In addition to over-fishing, over the last two decades, mass shrimp fry collection has become a further threat to the coastal ecosystem (Hoq, 2007). Trees have also been damaged by fishing boats being tied off to them. Estimated Maximum Sustainable Yields (MSY) of significant fishery resources, and existing acts/regulations to protect them have been covered well by Hoq (2007). His data is presented in Tables 1 and 2. However, little attention has been paid to the functional maintenance of this valuable resource. Consequently, there has been no sound management and research guidelines for the valuable mangrove fisheries (Islam & Haque, 2004).

## 1.2. Social-ecological system (SES) approach

Human social and economic systems are shaped by the ecological endowments of a region as a co-evolutionary process (Simmie & Martin, 2010). These processes occur in a variety of scales, from local to global. Hence, a stream of scholars has recently suggested that the focus of sustainability science should be on linked “social-ecological systems” (Berkes & Folke, 1998). The potential loss of fisheries, forests, and water resources is a major problem worldwide. Understanding of the processes that lead to improvements in or deterioration of natural resources is limited because scientific disciplines use different concepts and languages to describe and explain complex SESs (Ostrom, 2009). An SES is an ecological system intricately linked to and affected by one or more social systems (Anderies, Janssen, & Ostrom, 2004). Also, SESs are nested, multilevel systems that provide essential services to society, such as the supply of food, fiber, and energy (Binder, Hinkel, Bots, & Pahl-Wostl, 2013).

If we take small-scale fisheries, both inland and coastal, as an example here, they are important social-ecological systems in many developing countries, providing essential ecosystem services and livelihood opportunities to communities that are often considered amongst the world's poorest and most vulnerable (Be'ne' et al., 2010). Various research approaches have been developed and applied in different studies, in which the interaction between the social system and the ecological system has been explicitly considered (Binder et al., 2013). Concurrently, frameworks have been developed to establish a common language to structure research into SESs, and to provide guidance toward a more sustainable development of SESs (Pahl-Wostl, 2009).

## 1.3. Resilience thinking

At the core of the SES approach to managing human–nature relations are the concept of resilience (Glaser, Krause, Oliveira, & Fontalvo-Herazo, 2010). Resilience is a system's ability to reorganize and renew itself without loss of functions or diversity when disturbed (Alcorn, Bamba, Masiun, Natalia, & Royo, 2003). The resilience of any living (including social-ecological) system is centrally affected by the way the system reacts to change. Resilience thinking is a collection of concepts that combines many of the ideas developed in integrated, collaborative and ecosystem-based management with unique ways of dealing with the other dimensions of complexity (Duit, Galaz, Eckerberg, & Ebbesson, 2010). Furthermore, it has emerged as one conceptual framework with which to understand change and the multiple, cross-scale interactions in social–ecological systems (Holling & Gunderson, 2002; Berkes, Colding, & Folke, 2008). Although grounded in the ecological sciences (Holling, 1973), resilience has increasingly been tested and applied by natural and social scientists to examine a range of ecological communities (Gunderson, 2000), linked SESs (Berkes et al., 2008), and institutional and organizational arrangements (Anderies, Walker, & Kinzig, 2006). Resilience thinking is an important addition to the range of frameworks and approaches that can be used to understand and manage complex SESs like small-scale fisheries (Béné et al., 2011). Also, resilience thinking shifted the concept of sustainability from the early focusses on how to achieve and maintain stability, manage resources effectively, control change, pursue economic growth and increase human well-being, and deal with changes, disturbances, and uncertainties (Ahern, 2011; Berkes 2007).

## 1.4. Social-ecological dynamics

The social system and the ecological system although often treated separately, are two interrelated dimensions in the field of resource management. Some researchers had started to investigate the dynamics of integrated social systems and ecological systems to improve the resource management when the conventional resource management systems failed to achieve its goal (Ludwig, Hilborn, & Walters, 1993). Social-ecological dynamics focus on mechanisms for building social-ecological resilience in a world that is continuously changing (Folke, 2006). It explores the social aspects of ecosystem management, which includes adjustment of management practices and associated organizational and institutional structures and processes, guided by monitoring of feedback signals of environmental change (Olsson, Folke, & Berkes, 2004). According to Seixas (2002), Social-ecological dynamics can be used as tools to address questions of local knowledge, socio-ecological resilience, common pool or common property resource management, adaptive management, and stakeholder conflicts.

Considering the above-mentioned theoretical concepts, three major goals of this study are settled: defining the SMF as an SES in

**Table 1**  
Yield, exploitation rate and MSY of fisheries resources in SMF (Adopted from Hoq, 2007).

Species	Common name	Yield (tons)	MSY (tons)	Remarks
<i>Hilsa ilisha</i>	Hilsa	762	523	Over exploited
<i>Lates calcarifer</i>	Sea bass	150	160	Fully exploited
<i>Pomadasys hasta</i>	White grunter	232	457	Optimum
<i>Johnius argentatus</i>	Silver jew fish	548	593	Optimum
<i>Pangasius pangasius</i>	Fatty cat fish	135	92	Over exploited
<i>Plotossus canius</i>	Estuarine cat fish	141	92	Over exploited
<i>Macrobrachium rosenbergii</i>	Freshwater prawn	274	711	Optimum
<i>Penaeus monodon</i>	Giant tiger prawn or Asian tiger shrimp	180	226	Optimum
<i>Scylla serrata</i>	Mud crab	375	283	Over exploited
<i>Oyster</i>	Bivalve molluscs	3000	6000	Under exploited
<i>Gastropod</i>	Snails	35	113	Under exploited
<i>P.monodon fry</i>	Tiger prawn	1453 millions	672 million	Over exploited

**Table 2**  
Existing fisheries management and conservation rules in SMF (Adopted from Hoq, 2007).

Legislation	Summary of regulations	Implementing agencies
Indian Forest Act, 1878	<ul style="list-style-type: none"> <li>Empowers the Forest Department to manage the inshore and offshore fisheries in the Sundarbans and near shore 20 km marine waters</li> </ul>	Forest Department
Hunting and Fishing Rules, 1959	<ul style="list-style-type: none"> <li>A fishing permit is required to fish in reserved or protected frests</li> <li>Royalty may be levied on fish caught in tidal waters of reserved and protected forests</li> <li>It is illegal to use poison, explosives or fixed engine fishing gears, or to dam or bale water in reserve and protected forests</li> </ul>	Forest Department
Major Fisheries Regulations for SRF	<ul style="list-style-type: none"> <li>Khal Closure Regulation (1989): closes 18 khals permanently for fishing to ensure natural fish breeding</li> <li>Collection &amp; Export of Live Crab Regulation (1995): closes the entire SRF for crab fishing from December to February to ensure crab breeding</li> <li>Closed Season Regulation (2000): closes fishing in the entire SRF for five species (<i>P. pangasius</i>, <i>P. canius</i>, <i>L. calcarifer</i>, <i>M.rosenbergii</i>, <i>S. serrata</i>) during 1st May to 30th June to ensure natural breeding</li> </ul>	Forest Department
Wildlife Sanctuary Regulations, 1999	<ul style="list-style-type: none"> <li>Fishing is permanently prohibited in the three wildlife sanctuaries of SRF</li> </ul>	Forest Department
Other Regulations for Fisheries in SRF	<ul style="list-style-type: none"> <li>It is illegal to place nets across a khal and thereby completely block it</li> <li>It is illegal to sting a rope transversely across a khal</li> </ul>	Forest Department

order to provide guidance toward more sustainable development of the SMF; revealing the social-ecological dynamics of artisanal fisheries in the SMF so as to improve the mangrove resources' management, including fisheries, through identification of the different stakeholders' roles and conflicts; and finally, enhancing the socio-economic status of artisanal fishers through recognizing their different coping strategies as a means of resilience and reviewing the relevant management policies and recommendations related to artisanal fisheries in SMF on that basis.

## 2. Methods

This study was conducted in two artisanal fishing communities (Fig. 1), in Bamna Nil Dumor village (The Burigoalini Union<sup>1</sup>; Shyamnagar Upazilla<sup>2</sup> of Sathkira district) and Joymunir Gul (Chila Union, Mongla Upazilla under the district of Bagerhat). For the simplicity of description henceforth, these two study sites will be mentioned as site 1 and site 2 respectively. The two study sites are approximately 100 km apart from each other, and both are located on the edge of the SMF. Around nine thousand people, comprised of both low caste Hindu and Muslims live in those villages, most of whom rely on being able to extract resources from what is held to be the commons for their livelihoods. Over the course of four months (November 2013–February 2014) both qualitative and

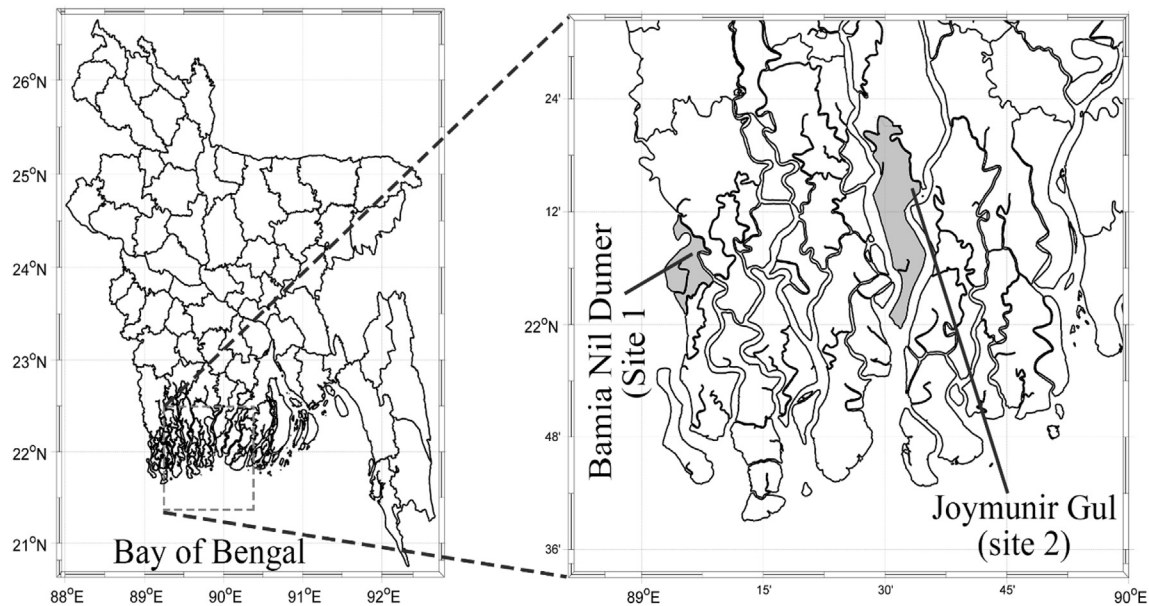
quantitative data were collected, drawing on multiple sources of evidence: participant observation, in depth-individual interviews, focus group discussions, stakeholder analysis, and documents. The use of various sources of evidence was critical to develop converging lines of inquiry (i.e., triangulation), to support my research findings, or at least to suitably coincide with them (Miles & Huberman, 1994; Patton, 2002; Yin, 2003b). Data collection was guided mainly by the SES, Social-ecological dynamics and resilience thinking framework (Ostrom, 2009; Seixas, 2002; Béné et al., 2011).

Participant observation (Patton, 2002) was conducted at fishing landing sites, markets and in households; recording information on the characteristics of fisheries (a type of gear, fishing methods, features of the fishing grounds) and conditions of the SMF area. Also, these observations provided insights into the social and economic environment in which fishers live, perform their daily activities, and experience multiple stressors (DeWalt & DeWalt, 2011).

In-depth individual interviews were conducted using a semi-structured questionnaire, consisting of questions regarding household characteristics, possessions and productive assets, extractions of mangrove forest resources, level of dependence on the mangrove forest, target fish species and gear used, risk perception, risks and shocks faced during fishing and in daily life, and coping strategies. In total, 140 interviews — 70 at each site — were conducted, 50 of which were with artisanal fishers (men 40 and women 10) who regularly use other mangrove resources besides fishing in the SMF. The rest were with the people involved in post-harvest activities and credit markets, some forest officials and non-governmental organization (NGO) officials. Each interview lasted

<sup>1</sup> Union is a rural local government unit of administration, headed by an elected representative. A Union consists of 10–15 villages on an average.

<sup>2</sup> Upazilla is a sub-district in terms of local government administration. It can also be referred to as a Thana.



**Fig. 1.** Map of Bangladesh where the study areas and some adjacent areas are marked by rectangles which is projected at the right image. In the projected area, the locations of two study sites are indicated by arrows.

40–50 min on average, and prior consent was ensured before tape-recording the interviews. The concept of saturation was the core guiding principle to determine sample sizes in this study (Mason, 2010). Interview respondents were selected through a combination of purposive and snowball sampling strategies (Robinson, 2014).

A focus group discussion (FGD) bringing together an assortment of local stakeholders — including woodcutters, fishermen, shrimp fry collectors (men and women), day laborers, marginal businessmen, the landless and rural elite — was conducted at each of the sites to determine their household livelihoods and resource profiles, vulnerability sources, seasonality of crop production or fishing, migration trends, profession changes, social categories and strategies, trends in resource use patterns during natural calamities and linkages with government agencies and NGOs. Stakeholders are defined as persons or groups with a direct or indirect interest, involvement or investment in specific resources (Grimble & Wellard, 1997). Stakeholder Analysis is a methodology used to facilitate institutional and policy reform processes by accounting for and often incorporating the needs of those who have a ‘stake’ or an interest in the reforms under consideration (Bryson, 2004). Stakeholder analyses are now arguably more important than ever because of the increasingly interconnected nature of the world, particularly when it comes to addressing shared challenges such as uneven economic development, poor educational performance, natural resources management, crime, AIDS, global warming, and terrorism. In this shared power world, no one is fully in charge; no organization ‘contains’ the problem (Kettl, 2015). Instead many individuals, groups, and organizations are involved or affected or have some partial responsibility to act. Figuring out what the problem is and what solutions might work is part of the problem, and taking stakeholders into account is a crucial aspect of problem-solving (Bardach, 1998). In this study, stakeholders who were associated with the extraction and marketing of the Sundarbans’ mangrove resources, and the organizations responsible for implementing Forest Department (FD) laws, were asked to define major problems in managing the forest and their relationship with the FD. Respondents were also asked to describe their interactions and

conflicts among themselves and with other stakeholder groups in the SMF.

Supplementary to these observations and interviews, secondary data/documents were collected from daily newspapers and study reports published by NGOs and local universities which were working with the small-scale fishers in the coastal areas of Bangladesh, and legislation issued by the Government of Bangladesh. This secondary data is particularly useful in providing information about illegal and unlawful activities that take place in the SMF. Also, these documents contained information relevant to the case studies, such as types and characteristics of resources, socio-economic events, institutions and governance systems. They helped to contextualize the interview and observation data (Bowen, 2009); and, also proved useful in validating such data (Yin, 2003b).

Analysis of data followed standard protocols for qualitative data analysis (Miles & Huberman, 1994). Initial analysis included coding of interview transcripts and notes from the observations. The coding process was used to generate categories and themes (Creswell, 2013; Miles & Huberman, 1994) based on the objectives. Quantitative data obtained from interviews were analyzed using Excel spreadsheet software.

### 3. Findings

#### 3.1. Social-ecological and economic dynamics in the SMF

##### 3.1.1. Fishing operations

Fishermen’s access to the fishing ground mainly depends on ownership of fishing boats. 25% and 21% of the respondents in site 1 and site 2 respectively lacked fishing boats of their own, meaning that they were restricted to fishing shallow inshore waters (Table 4). Nevertheless, 79% of these poorer fishers in site 1 and 88% in site 2 worked together with other fishers (nearest kin, neighbors or friends in the community) either as day laborers or borrowing their boats to gain access to the local fishing grounds (Table 4). One such respondent (Rahim Bhyuan, age 57) from site 1 said:



**Table 3**

Co-operation and conflict among stakeholders in the present study's research locations.

Stakeholder interaction	Co-operation	Conflict
Fishermen-fishermen	<ul style="list-style-type: none"> <li>• Share boats, nets, fishing knowledge etc.</li> <li>• Help one another whenever needed &amp; Supply news of one another's family.</li> <li>• Supply food each other if needed</li> <li>• Protect against the Dacoit cooperatively</li> </ul>	<ul style="list-style-type: none"> <li>• Conflict over setting nets.</li> <li>• Conflict at the time of illegal wood cutting and other mangrove resources</li> </ul>
Fishermen-trader	<ul style="list-style-type: none"> <li>• Loan money</li> <li>• Net, boat and food support to fishermen family</li> <li>• Marketing essentials supplied at the fishing place</li> </ul>	<ul style="list-style-type: none"> <li>• To get higher price some fishermen sold fry to another trader</li> <li>• Without having paid the loan fishermen abscond</li> <li>• Traders cheat with the fishermen when counting fry</li> </ul>
Fishermen-dealer	<ul style="list-style-type: none"> <li>• If the fishermen cannot collect the fry, dealer bears their family need.</li> <li>• Dealer tries to free the fishermen from Dacoit by lending money.</li> </ul>	<ul style="list-style-type: none"> <li>• Sometime dealer does not pay the fishermen</li> <li>• Don't pay the actual price</li> </ul>
Fishermen-creditor	<ul style="list-style-type: none"> <li>• When fishermen don't collect fry, creditors pardon them from their payback % and pay market rate</li> </ul>	<ul style="list-style-type: none"> <li>• Some fishermen do not go to collect fry after they received loan.</li> <li>• Sometimes creditors take too much interest from the fishermen</li> </ul>
Fishermen-Forest Department	<ul style="list-style-type: none"> <li>• Gives security to the fishermen</li> <li>• Co-operates for cutting wood and fishing illegally</li> </ul>	<ul style="list-style-type: none"> <li>• Forest office takes more fees from the fishermen.</li> <li>• Forest officials take bribe from the fishermen</li> </ul>

**Table 4**

Fishing operations.

Subjects	Variables	% in site 1	% in site 2
Patterns of fishing activities	Partnerships	79	88
	Individual	21	12
No. of fishing boats	1–2	64	61
	3–4	11	18
	No Boats	25	21

**Table 5**

Subsequent occupation (%) in the study areas.

Variables	% in site 1	% in site 2
Agriculture	10	16
Crab Collection	16	13
Fry Collection	15	18
Golpata Cutting ( <i>Nypa fruticans</i> )	13	20
Fuel Wood Collection	17	15
Labor	13	10
Boat making	8	2
Netting	3	2
Nil	5	4

"As a full-time fisherman, I also wish to have my boat and fishing gear, even if the income flow is erratic and small. If it can provide the basic needs of my family — food and clothing — that's enough for me. But I don't have the required capital to buy a boat. Even the dadonder (local moneylender) does not want to give us a loan during this lean period as we have no boat to start with."

Fishing in the Sundarbans, however, should not be done solo. To avoid tiger attacks, a three-person team is needed: one to work the net, one to steer the boat and one to serve as a watchman looking out for tiger movement. Women and children who work collecting shrimp fry, however, do so alone. Social and religious constraints prevent women from fishing in groups. Many in the artisanal fishers' community, however, are not able to be fully engaged in the profession due to lack of essential equipment. Thus, the pre-existing economic problems of the ultra-poor have ballooned all out of proportion.

### 3.1.2. Socio-economic divergence

Primary livelihoods of respondents at both sites were active fishing and fishing-related secondary businesses like fry transportation and trading. When the income from fishing alone is not sufficient for them, the SMF offers a scope of alternative livelihoods. Most of the respondents took on a supplementary occupation to compensate for the small income from fishing. Alternative livelihoods at the sites observed here were agriculture, crab collection, shrimp fry collection, harvesting *Nipa fruticans* leaves, fuelwood gathering, boat making and taking whatever day-labor jobs neighbors were offering. However, collecting *Nipa fruticans* leaves (20% in site 2) and fuelwood (17% in site 1) from SMF were the preferred supplementary occupations for respondents at both sites (Table 5).

### 3.1.3. Biodiversity and fishing gear used

The SMF has a rich diversity of aquatic and terrestrial flora and fauna. There are about 334 plant species, including 35 legumes, 29 grasses, 19 sedges and 50 true mangrove plant species (Chaffey, Miller, & Sandom, 1985, p. 187). The fish fauna of the Bangladeshi SMF includes 53 pelagic and 124 demersal species (Sarker, 1989). Among the invertebrates, some mollusks and crustaceans constitute important fishery resources. About 20 species of shrimp, 8 species of lobster, 7 species of crab, several species of gastropod, and 6 species of pelecypod have been reported in the Sundarbans (Pasha & Siddiqui, 2003, pp. 417–421). Among shrimps *Penaeus monodon*, *Metapenaeus monoceros* and the mud crab *Scylla serrata* are commercially valuable. In this study, respondents identified several important types of fish in the adjacent rivers and mangrove areas. These included: Golda (*Macrobrachium rosenbergii*), Bagda (*Penaeus monodon*), Koi (*Anabas testudineus*), Shoal (*Channa striata*), Magur (*Clarias batrachus*), Tengra (*Mystus bleekeri*), Ilish (*Hilsa ilisha*), Vetki (*Lates calcarifer*), Datina (*Acanthopagrus latus*), and Pangus (*Pangasius pangasius*). Regarding fish and shrimp availability in the mangrove area, most of the interviewees stated that mangroves play an important role in a breeding ground and nursery for aquatic animals.

There are at least 14 different fishing methods and types of gear used by the fisherman in the Sundarbans (Haque, 2003). In this study, there were 5 different types of gillnets (i.e. drift gillnet, fixed gill net, large mesh gillnet, bottom set gillnet and mullet gillnet), and 2 types of set bag nets (estuarine and marine set bag nets) primarily used at both sites. Fishers at both sites used the same types of fishing nets though. Most commonly used were: 'Basan Jal' (gill net), 'Jhaki Jal' (cast net), 'Ponamara Jal' (a push net of the set bag net type), 'Keoa Jal', 'Tana Jal' (push net/dragnet). At site 2 they also used *Chorpata*, *Behundi Jal* (estuarine set bag net), *Ilish Jal* (gill net). In the context of the present study, shrimp fry fishing by using set

bag nets has been found highly damaging to biodiversity and fish stocks.

### 3.1.4. Income for livelihoods

In FGDs, respondents at both sites stated that their earnings had increased (attributed to an increase in the price of fish, not an increase in the size of their catch per unit of effort), compared to previous years, but their livelihood wellbeing did not improve due to the seasonality of the profession. Furthermore, more people had become engaged in fishing (especially shrimp larva/fry fishing) as the occupation of last resort following bans on wood cutting by the Forest Department, price hikes for fish and daily necessities, inherent poverty, and a lack of alternative employment, among other factors. A Crab collector (Karim Mia, Age 58) from site 1 said that:

“I have six family members. Earlier when I caught crabs, I always released the young ones. But now sizable crabs are dwindling. My current average income is around Taka 195 /day (€ 2). So now I don't release young crabs anymore. I keep them to supplement our daily food. We know that we are destroying our future livelihood by doing so, but I have no other choice.”

Also, respondents at both sites stated that fish catches were getting smaller at an ever-increasing rate. Respondents identified the fundamental causes for smaller catches as an increased number of fishers, use of poisons as a fishing method (spreading poisonous liquid chemicals in canals to get fish to float to the surface), siltation, etc. Moreover, small-scale fishers were catching more young fish and crabs by reducing the mesh size of their nets.

### 3.1.5. Extra costs sustained in fishing operations

For various reasons overhead costs for fishing in the SMF have been increasing, and fishers must compensate for this loss by increasing the size of their catch by any means possible, legally or illegally. Forest department officials have been known to take bribes from fishers to allow them to exceed their legal catch limits and to cut down mangroves illegally. Respondents said that they covered the cost of these bribes by extracting still more resources from the SMF. Such practices were evident in the FGD at site 2. Fishers there (Rahman Mia 47, Moynal 40 and Shemol Das 36) mentioned:

“We are fishers in the Pasur range of the Sundarbans. We must pay a certain fee for a fishing permit. But the fisheries officials issuing the permits always charge a bit extra. Our weekly income from fishing is about Taka 900 (€ 9) per person. So, we must have some savings for paying the regular fees as well as the extra money charged by the officials. But in the Sundarbans area, there are some active, organized crime elements. They divide the total area into different zones for collecting extortion. We must pay Taka 500 (€ 5) per week as extortion. Moreover, some corrupt forest officials also charge extra money for fishing. In this way, most of our incomes go into the pockets of others. But we must survive. So, we compensate our loss by catching more fish that are allowed according to our permits, keeping them hidden under the deck of our boat.”

### 3.1.6. Mangrove resources used to generate livelihoods

Mangrove forest resources which respondents identified as very important for their everyday lives in the areas studied were: firewood for household consumption and/or small-scale marketing, poles and mangrove leaves (especially *Nipa fruticans*, “Golpata”

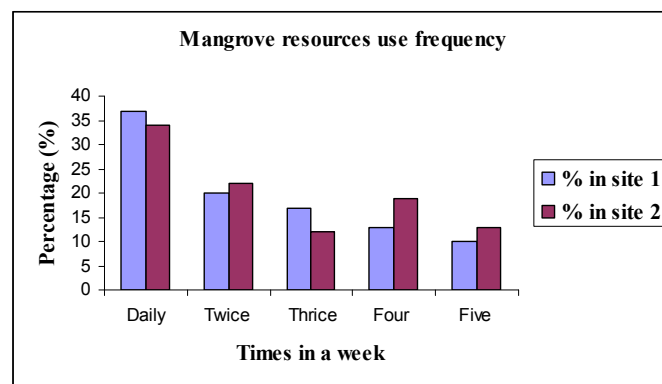


Fig. 2. Frequency of using mangrove resources in a week.

leaves) for housing and boat construction, and of course prawns, fish and crabs as their staple food and primary cash product. Many of the respondents (33% in site 2 and 37% in site 1) used mangrove forest resources daily (Fig. 2) and showed a complete dependency on these resources for their livelihoods. The roofs of most of the houses in the study sites were made of *Nipa fruticans* leaves. During the FGD at both sites, deforestation of mangroves was discussed. Respondents stated that illegal logging and household consumption in the face of population growth were the main causes of mangrove deforestation in the SMF. Also, climate change issues regarding of higher temperatures and higher salinity in the SMF rivers, anthropogenic disturbances such as shrimp farming, and natural disasters (cyclones and flooding) were responsible for the deterioration of mangroves in the SMF. One respondent (Sajib Das 43) at site 2 told us,

“Fifteen years ago, I could catch more than 4 kg of different types of fish within 6 hours fishing in the Chilla River. Besides fishing, sometimes I went to catch crabs in nearby mangrove areas, and I was happy with the amount of my catch. But now I cannot get enough fish or crabs to make a living. I do not know why it is happening and how I will survive. I might change my occupation rather than continuing fishing.”

The reduction in mangrove forests, as well as mangrove inundated areas, has had a negative impact on the artisanal fishermen's livelihoods. All respondents in both sites mentioned that their present occupation (fishing) was hampered by the continued destruction of mangrove forests. The consequences were less fish and fishery resources, livelihood changes, changes in fishermen's professions, and finally a sharp decline in fish harvests in recent years.

## 3.2. Analysis of stakeholders

### 3.2.1. Stakeholders in the SMF

Different stakeholders can be found to be involved in the SMF. Our emphasis here, however, is on the stakeholders in the sites studied. Stakeholders in both areas can be categorized as follows:

- Local user communities - These are the artisanal fishers, shrimp fry collectors, *bawali* (wood collectors), *mawali* (honey collectors), and *golpata* leaf (*Nipa fruticans*) collectors. People of these communities reside close to the mangrove forests, having a shared interest in maintaining the mangrove resources.
- Local community - People of this community have an indirect interest in the mangroves as they are not dependent on any

mangrove resources. But they live in the mangrove forest to be protected against cyclones, seawater intrusion, etc.

- Remote user communities – People of these communities' hail from faraway places and use resources — e.g., swamps and cleared areas — for fish and prawn farming.
- Government agencies – The Forest Department and the Fisheries Department are the two primary stakeholders in the areas studied, with the responsibility to manage and protect mangrove resources. They implement the rules and regulation through direct and indirect interactions with local fishing communities.
- Supporters of mangrove user communities – The primary support groups helping mangrove user communities tend to be non-governmental organizations (NGOs) and voluntary agencies. Money lenders (*dadondars*) also fall into this category, as they provide loans to fishers to invest in better gear and boats. *Sosilon*, *Gonomoki*, *Uttoron*, *ASA*, *BRAC* and *Action Aid* were the prominent NGOs active in site 1. The NGOs most active around site 2, on the other hand, were *BRAC*, *BRDB*, *Matshajivi Samity*. Microcredit is the primary business of NGOs in the study areas. However, respondents stated that they obtained financial and technical help from the NGOs during times of crisis they had been through.

### 3.2.2. Co-operation and conflict among the stakeholders in SMF

During the FGDs, respondents told of their interaction, co-operation, and conflicts with other stakeholders. The co-operation and conflicts at the community level among stakeholders at each site are described in Table 3.

### 3.3. Risk and vulnerability

During the FGDs at both study sites, artisanal fishers discussed different types of risks and vulnerabilities that they faced while fishing in the SMF. Fishers acknowledged fishing in the SMF to be risky, as tiger-human conflicts claim fishers' lives and affect the livelihoods of their family members. Also, fishers were afraid of being assaulted and concerned that local bandits, "*dacoits*," would steal their boat or nets. Similarly, when disasters strike in the form of cyclones, the loss of fishing gear, boats, livestock and other household assets can dramatically impact entire livelihoods. In such cases, families often must rebuild their lives and livelihoods from scratch. Moreover, the death of a working-aged household member can send the whole family into poverty and extended trauma.

### 3.4. Enhancement of artisanal fishers' social-economic & ecological resilience

Artisanal fishers in the SMF have adopted different strategies to cope with current changes. The coping strategies adopted by the fishers in this study areas were as follows:

#### 3.4.1. Partnerships

Family cohesion is a crucial aspect of livelihood security. Fishers' households first cope with vulnerability through family cooperation. Children also help generate household income. At both sites studied many boys as well as women search for livelihood options to help support their families. When the father grows old, usually a son occupies the position of the skipper, giving the father some easy job on land, like making or mending nets. However, fishers build partnerships with other fishers besides family members to increase the production and improve safety (to protect them from tigers as well as robbers).

#### 3.4.2. Violation of existing fisheries management laws and regulations

Fishers ultimately cope with vulnerability by putting more pressure on natural resources as they have limited alternative livelihood opportunities. Despite the ban of shrimp fry collection imposed by the government, fry collecting continued, forcing fry collectors to bribe local law enforcement officials. Many fishers also fish during the illegal off-season or in restricted areas. Non-targeted and protected species were caught out of desperation during lean seasons and to get some extra money in peak seasons.

#### 3.4.3. Diversification, occupational and geographical migration

Although fishing was the primary occupation in both study areas, fishers earn extra money by collecting honey, wood, and golpata (*Nypa fruticans* leaves) cut from the SMF. When fish become less accessible, some fishers temporarily change their primary occupation to boat making, netting, agriculture or wage labor. Many fishers have migrated to the nearby islands to do fish drying during the winter season. Multi-species fisheries of Sundarbans provide unique opportunities for fishers to switch target species. Occupational diversification was the most common instrument to cope with livelihood adversity.

#### 3.4.4. Women sharing economic responsibility

The reduction in the fishermen's income was often compensated by an increased role for women in livelihood strategies. Women in the SMF supplement their household income by collecting firewood, catching shrimp fry in nearby rivers, taking the fish to market or fish drying, and working in the aquaculture farms. Women's secret savings often provide a form of insurance for the family, and they can further help their families with small gardens in their yards or on their rooftops. Access to microcredit for women not only empowers them in household activities, but it also enables them to raise poultry and other livestock to meet their families' everyday needs during lean periods or to overcome sudden shocks like an unexpected illness or death of one of the male breadwinners.

#### 3.4.5. Sharing knowledge and exchanging information

Fishers at both sites shared expertise and exchanged information as semi-professional consultants at times. In the case of looking for solutions to problems related to ecological changes and subsequent changes in their profession, the fishermen discussed the matter with family members, neighbors, their local chief, wise village elders, friends and NGO officers. However, in most cases, the chief (*Sardar*) in each fishing village had the initial right consult with other stakeholders regarding solutions to existing problems. According to fishers at both study sites, the mode of ecological knowledge transmission was briefing and practicing, and then mentoring and giving instruction to the young. It came up in both FGDs, however, that the fishermen did not want their children to become fishermen, but rather to get enough of an education to find jobs outside of the Sundarbans' SES.

### 3.5. Management policies and approaches to artisanal fisheries in Bangladesh

Based on the secondary data gathered for this study, several management policies were in force regarding artisanal fisheries in Bangladesh. These fell into two categories: *actual* and *possible* management approaches. Gear restrictions, protected areas or reserves, and indirect management were considered as real. Habitat improvement and restoration, and re-stocking different fish in mangrove habitats were regarded as possible management approaches. Existing fisheries management and conservation rules in



SMF were itemized in Table 2.

### 3.5.1. Gear restrictions

To protect the development of coastal fisheries in Bangladesh, certain types of fishing gear have been banned or restricted as basic management practices. For instance, a regulation was introduced requiring an estuarine set bag net (ESBN) to have a minimum mesh size of 30 mm to reduce the negative impact of ESBN fishing, on the theory that the larger holes would allow younger fish to escape, keeping only full-grown ones. This restriction, however, resulted in virtually no catch at all with ESBNs, since such gear was, in fact, being used to target primarily younger fish. Hence, a complete withdrawal of this type of gear from the estuarine environment has been suggested (Khan, Mustafa, Sada, & Chowdhury, 1989).

### 3.5.2. Protected areas or reserves

Protected areas were considered as a powerful tool for offshore and marine fisheries' management. However, as of this writing, no report is yet available regarding the practice of setting aside protected areas within Bangladesh's mangrove fisheries. Even so, this might not produce intended result in mangrove fisheries' management because most of the mangrove fisheries are dependent on breeding stock coming in from the deep sea. On that basis, however, protected areas within the mangrove region could eventually enhance the productivity of offshore fisheries (Islam & Haque, 2004).

### 3.5.3. Indirect management

Indirect management approaches included reducing the loss caused by by-catch in commercial and artisanal fishing operations, as well as reducing fish mortality during sorting, transporting, stocking and other such processes. One possible option along these lines for helping former ESBN users may be to engage them in some different styles of fishing that are more biologically sustainable. Examples of such systems include trammel net and bottom longline fishing, which are reported to have the potential to create a good number of employment opportunities for fishers in transition (Islam, 2003; Kamal, 2000).

### 3.5.4. Possible management approaches

To restore depleted fisheries, as well as to resolve some of the conflicts inherent in traditional fisheries' management over issues such as gear restrictions and protected areas, new approaches are being considered. Though these methods have been used in many parts of the world, in Bangladesh they are somewhat hypothetical at this point. Thus, they are referred to as "possible management approaches". Two such management tools are habitat improvement and restoration, and stock enhancement and ranching (Islam & Haque, 2004). Habitat restoration for the mangroves of Bangladesh was begun in 1966 with afforestation using artificially planted mangroves. This program continued until 1990, during which time an area of 120,000 ha was re-planted, substantially increasing the total mangrove forest area (Islam and Wahab, 2005b). However, no information is available as to how this program affected the productivity of fisheries in these areas.

### 3.5.5. Management applied to (artisanal) marine fisheries

Marine fishery management in Bangladesh has been primarily based on seasonal restrictions and input controls, i.e., licensing of fishing vessels. The Department of Fisheries has none of its vessels for research or monitoring, surveillance, and control (MSC), and for the latter purpose, it relies on assistance from the Bangladesh Navy and Coast Guard. The government had banned the use of set bag nets, and there is a complete ban on shrimp fry collection along the coastal belt to preserve biodiversity. All these management

activities were executed under the Marine Fisheries Ordinance of 1983, as well as the Marine Fisheries Rules of 1983. However, the implementation of these rules has not been conclusively carried out, and the lack of MSC resources provided to the Departments of Forest and Fisheries allows fishers to break these rules with impunity. Consequently, biodiversity and fish stocks have been alarmingly depleted.

### 3.6. The Sundarban Mangrove Forest (SMF) as an SES – direct observations

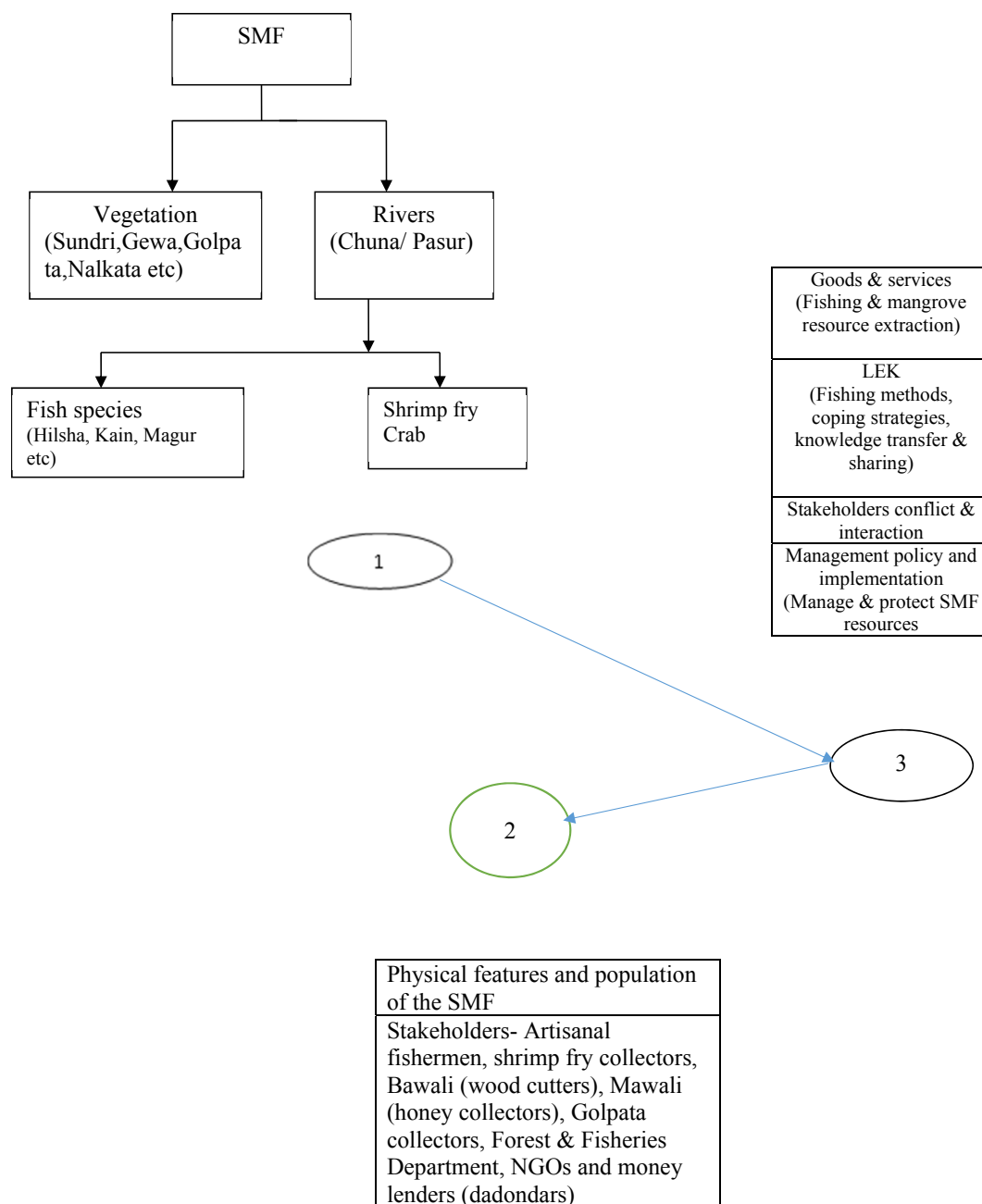
The concept of Social-ecological systems (SES) has emerged to make the connections between the human and ecological components of environments more explicit, as well as focusing on the feedback mechanisms by which the two are coupled (Folke, Hahn, Olsson, & Norberg, 2005). A schematic representation of an SES shows the ecological component, the social component and the interphase where links and feedback mechanisms operate (Beatrice, 2006). Based on the above discussion, the SMF includes a social component (human), an ecological component (mangrove resources) and an interphase (local ecological knowledge, stakeholders' interests, and money lenders' or middle-men's roles) by which they are linked in mutual interaction. Hence, the SMF can be defined as an SES (Fig. 3).

## 4. Discussion

The fisheries in the mangrove forests of Bangladesh are characterized by a very high degree of endemism and diversity. Fishing activities in the mangrove areas are dominated by artisanal fisheries, which include many different types of fishing gear and crafts (Islam & Wahab, 2005). The status of mangrove fisheries in the SMF over the last few decades has had two distinct phases: the first phase showed an increasing trend until 1988–89, after which the second phase has been one of continuous decline since then. This pattern indicates that the mangrove fisheries are being damaged by over-fishing, by habitat degradation, or both (Islam & Haque, 2004). Too many young shrimps and fish are killed before reaching reproductive maturity due to the intense demands being placed on these resources. This over-exploitation has been shown to cause a continuous decrease in the availability of shrimp fry from year to year, with disastrous impacts on both artisanal and commercial fishing operations (Deb, 1998). One aspect of the over-exploitation of near-shore fisheries within the Sundarbans' ecosystem is the extensive use of set bag nets for shrimp fry collection. This poses a major threat to coastal ecosystems, damaging the nursery grounds of many species of aquatic fauna, hurting both newly planted mangroves and older protected mangrove forest areas (Hoq, 2000).

Artisanal fisheries are labor intensive, capital extensive, traditional in nature, and pursued subsistence purposes, commercial profits or both. Inshore, estuarine and coastal fisheries of the Sundarbans provide a source of livelihood for about 200,000 fishers operating daily in the Sundarbans waters (Islam & Haque, 2004). The artisanal fishermen interviewed in this study told of their primary reasons for taking up this occupation: decreased local rice production, increased family size, the hope of building a profitable business and finally a government ban on mangrove wood cutting. The average monthly income ranges from 3100 to 4000 Taka (30–38 €) at site 1 and 4100 to 5000 Taka (41–48 €) at site 2, which is less than the country's overall per capita income (BBS, 2015). The incidence of absolute poverty, where deprivation is so severe that the basic needs to sustain life at the minimum level necessary for survival can scarcely be met, is quite high in these areas.

The living conditions for artisanal fishing families exhibit



**Fig. 3.** Visual representation of the Sundarban mangrove forest (SMF) as SES -1.Ecosystem function (SMF), 2.The social components, 3.The interphase (links).

considerable variations between countries and continents in the developing world. In this study, respondents stated that their incomes increased compared with the previous years, but their livelihood is not improved. In general, this is merely an effect of inflation. The reasons for less livelihood development are population increases, government bans on wood-cutting and fry catching, lack of industries and a poor communication infrastructure. There are different exogenous and endogenous pressures affecting fishery resources in the SMF. With increased population density and increased demand on the fisheries sector nationally and globally, people are violating existing fishery regulations (under-size fishing, fishing during the breeding season, using environmentally harmful fishing gear, etc.) and damaging several (99% of the total catch) species of fish larvae while collecting shrimp fry (Khan & Latif, 1997). However, respondents in both study areas stated the same

things: Households in these areas depend directly on the mangrove forest for fish and wood. Lack of employment opportunities and income alternatives for young people and women are major economic problems. This intensifies the exploitation of mangrove resources, which are the only available source of subsistence materials and monetary income, leading to an ever more widespread and unsustainable dependence on these resources. This reliance is nowadays a paramount concern for villagers as they perceive a decrease in the availability of mangrove resources (Fontalvo-Herazo, Glaser, & Lobato-Ribeiro, 2007). The present study provides further evidence of the extent of this dependency, as the majority of the respondents interviewed here use mangrove resources daily.

The leading causes of environmental degradation and deforestation are anthropogenic. Burgeoning populations, over-

exploitation of mangroves and conversion of mangrove forest areas to settlements, rice fields, salt beds, tourist resorts and industrial facilities are some of the primary causes of mangrove degradation (Primavera, 2005; Semesi, 1998). But clearing forests for timber and the wood-chip industry, and excessive extraction of timber for firewood have also led to the degradation of extensive habitats (Semesi, 1998). Other causes of deforestation are the over-use of mangrove wood as an alternative household fuel, and as raw material for boat making and house construction. Houses made of *Katcha* and *Golpata* at both research sites show how vast numbers of mangroves are used in making roofs.

Another source of ecological damage has been the continued expansion of intensive aquaculture. In the Philippines alone half of the 279,000 ha of mangroves lost between 1951 and 1988 were due to aquaculture development (Primavera, 2000), causing significant social and environmental problems. This study as well includes reports from artisanal fishers of decreases in mangrove areas due to expanded shrimp farming in the SMF and adjacent areas.

The shrimp farming industry is mostly dependent on wild sources for fry. Collecting tiger shrimp fry along the coastline and in the nearshore waters of the Bay of Bengal has become a profitable occupation for thousands of people. This has had a devastating effect on shrimp fry and fish larva populations for many other species as well, which tend to get caught in the same nets. It is reported that the target species, tiger shrimp (*P. monodon*) actually constitutes a tiny portion of the total catch: For every *P. monodon* caught, 12–551 post-larvae of other shrimps, 5–152 fish larvae and 26–1636 macro zooplanktons are removed from the rivers in Bangladesh's mangrove forest, and thus wasted (Hoq, Islam, Kamal, & Wahab, 2001). Over-exploitation has led to a decreasing availability of shrimp fry from year to year, with disastrous impacts on artisanal and commercial fisheries (Deb, 1998). Furthermore, the shrimp fry collecting business poses a severe ecological threat not only to aquatic biodiversity by direct killing vast numbers of the fish and shrimp but also to other animals such as aquatic birds and reptiles by reducing the availability of their primary foods.

Based on the above discussion, mangrove destruction and careless exploitation of fishery resources have had significant negative impacts on the livelihoods of artisanal fishers in the SMF. These negative results are manifested in a reduced availability of fish and other resources. Thus, many artisanal fishers will need to change professions shortly.

The present study shows that the coping strategies of fisher households in the SMF are often complex and diverse, and encompass measures and mechanisms both within the fisheries sector and beyond it. The preferred method of coping with vulnerability is through family cooperation, yet they will also enter into partnerships with fishers outside of their family circles to increase production and provide added safety. They seem to have few moral reservations about violating existing fisheries management laws and regulations, even if they are severely damaging their collective prospects in doing so.

When fish catches are still not sufficient to survive on, artisanal fishers may temporarily change their primary occupation. The diversified livelihoods that many fisherfolk practices demonstrate their capability to make use of the varied resources and skills available to them (Béné, Macfadyen, & Allison, 2007). According to Salagrama (2006), coping strategies adopted by fishers are strategies for enhancing their current livelihood systems, diversifying into other occupations (whether at the individual level seasonally, or at the household level, where different members work in various activities) or sometimes shifting to an entirely new business.

The erosion in the fishermen's income is often compensated by the role of women in livelihood strategies. Multiple income strategies, such as males doing the fishing and females doing

processing and trading, spread the risks involved. Gender differences play an important role in livelihood adaptation strategies. Women's control over fish drying and processing (e.g., smoking) provides them with income that can be used for investment, and with products that can be sold after the fishing season is over. Women in the SMF may also supplement their household income by collecting firewood, catching shrimp fry in the nearby rivers or working in local aquaculture farms.

Fishers at both studied sites tend to work on collective problem solving first of all by sharing knowledge and exchanging information with family members; and after that with neighbors, heads of the society, taught persons, friends and NGO officers. Communities are rarely comprised of just one group of local stakeholders; instead they are defined by complicated patterns of subgroups with different perceptions, interests, resources, and levels of influence (Carlsson and Berkes, 2005; Nygren, 2005). This heterogeneity most often also extends to the patterns of resource use within communities, with different groups focusing their extraction efforts on various parts of the natural system or different types of resources. Such differentiation in local initiatives could be assumed to influence the type and amount of ecological knowledge obtained by various user groups. In the present study, we can see how different stakeholders in the SMF are involved in the extraction, marketing, and management of the Sundarbans' resources. These stakeholders include artisanal fishermen, shrimp fry collectors, *bawali* (wood collectors), *mawali* (honey collectors), *golpata* (*Nypa fruticans* leaves) collectors, and representatives of governmental agencies such as the Departments of Forest and Fisheries (who try to manage and protect mangrove resources). Also, NGO's and money lenders (*dadondars*) are the prominent stakeholders in the SMF. Thus, the stakeholders in both study areas are interlinked through co-operation and conflicts.

## 5. Conclusion

The mangrove forest and associated fisheries are valuable resources for Bangladesh, playing a significant role in the economy of the country. The SMF has been reduced alarmingly, with visible impacts on its fish stocks and fisheries. Over-fishing and over-exploitation of plant and wildlife species are placing high stress on the viability of this ecosystem. Healthy mangrove systems in Bangladesh not only help to meet economic needs, in part through the fishery resources they provide; they also protect lives and properties from natural disasters.

As an SES, the SMF includes a social component (human), an ecological component (mangrove resources) and an interphase (local ecological knowledge, stakeholder's interest, and money lenders or middle man roles) by which they are linked in mutual interaction. This system is operating at a far from the optimal level at present though: The social-ecological dynamics of the SMF are having a negative impact on artisanal fishers' livelihoods. Hence, there is an urgency to update existing policies and management issues for the sustainable extraction of the SMF resources, eventually contributing to the improvement of the artisanal fishers' livelihoods.

Furthermore, the analysis of the dynamics of integrated social and ecological systems can help us understand the complex nature of several management problems. Understanding the complex nature of social-ecological dynamics leads us to recognize the importance of the qualitative analysis in natural resource management science. The present study attempts to provide some management and policy recommendations, useful for the sustainable extraction of Sundarban mangrove resources, based on both primary and secondary data. This sort of sustainability will be vital to long-term improvements in the lives of artisanal fishers and

other stakeholders in the SMF. With an emphasis on the sustainable use of mangrove fishery resources then, the following recommendations for SMF management should be considered:

- Fisheries managers and other management authorities should have sufficient knowledge of the SMF ecosystem, including fish stocks and fishing household living strategies, to incorporate such insight into the process of management planning. They can gain this knowledge by exchanging information with the local artisanal fishermen, who are excellent sources of local ecological knowledge regarding the fishery resources in the SMF, from which they are obtaining their livelihoods. Eventually, this will lead to the formulation of a proper management plan.
- The boundary and enforcement of protected areas would be a powerful tool in offshore and marine fisheries' management. Thus far no reports have been published regarding the practice of establishing protected areas within Bangladesh's mangrove fisheries, yet it can be confidently theorized that such a move would not only protect biodiversity in the immediate area but that it would also enhance fish stocks in offshore and marine fisheries. This practice of reserve areas within the SMF should thus be tested as a tool in both near-shore and offshore fisheries management.
- Public support and community participation are primary requirements for successfully establishing any form of the regulatory system. Hence, adaptive management systems (such as community-based fisheries management or co-management) should be developed for better understanding of the social-ecological systems of the SMF.
- In structuring management systems and policy implementation, socio-economic and cultural heterogeneity should be addressed. Attention should be paid to the influence of local authorities, religious practices in the region, prevalent levels of education, and the political dynamics of the community regarding the effects these factors will have, directly or indirectly, on the implementation of the management plan being considered.
- Restriction on fishing during breeding seasons should be strictly implemented by the responsible authorities (Forest and Fisheries Departments) in the SMF. During those periods, alternative livelihoods for the fishermen should be arranged by the government.
- Alternative income-generating employment should be arranged for women in activities other than shrimp fry gathering.
- Steps should be taken to improve communication and transportation infrastructures in the SMF. A lack of adequate foundations of these sorts prevents fishers from being paid the full market value for their catch. They cannot sell in the local market as it is too far away, so they must sell at a low price to a middle man. To remedy this situation, the government should take steps to build roads, bridges, set up modern mobile phone networks in remote market negotiations and public transportation systems in the SMF.
- The current sectoral policies in the SMF need reorientation. New policies on land and water use and human settlements should be adopted to ensure institutional coordination. The legislation is necessary to regulate all activities negatively impacting local health and livelihoods; and to establish protective standards, mitigation, monitoring, and enforcement.
- Trammel net fishing and the bottom longline fishing should be introduced in the SMF area to reduce the mass use of EBN systems in this area. These practices can be added as a feasible option to engage fisherfolk in more ecologically sustainable fishing systems.
- Finally, Law and order functions need to be separated from management roles, and there is a critical need to train forest

management officials in how to engage local people in the natural resource management-related decision-making process.

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